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In many instances apparent exceptions turned out on reëxamination not to be exceptional; and although our work has been only tentative, enough has been found to demand the attention of synantherologists.

TABLES OF ACHENIAL HAIRS, &c., OF COMPOSITÆ.

- I. Vernoniæ: as in Asteroideæ.
- II. Eupatoriæ: do.
- III. Asteroideæ. Duplex hairs, usually bifurcate, and often unequal, acute at tips. Hairs sometimes few or obsolete: sometimes as in Inuloideæ. No elaters.
- IV. Inuloideæ. Duplex hairs, usually obtuse and equal. No elaters.
- V. Helenioideæ: as in Asteroideæ. Crystalloids in endocarp.
- VI. Anthemideæ. Achenes usually glabrous; but having pericarp cells with spiral filaments. (Glands in *Achillea* within pericarp cells.)
- VII. Senecionideæ. Duplex hairs, having divisions equal, with elaters or filaments, which escape when moistened.
- VIII. Calenduleæ, probably as in Senecionideæ (with multicellular hairs interposed in some).
- IX. Arctotideæ, as in Asteroideæ.
- X. Cynaroideæ. Some as in Asteroideæ (*Carlina*, *Xeranthemum*). Some as in Cichoriaceæ (*Cnicus*, &c.). *Arctium*, *Centaurea*, *Echinops*, &c., have simple hairs on achene like those of perianth.
- XI. Mutisieæ, as in Asteroideæ.
- XII. Cichorieæ. Achenes glabrous, with denticulate epidermal cells. Endocarp having filaments, enclosing crystalloids.

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INSTINCT AND MEMORY EXHIBITED BY THE FLY- ING SQUIRREL IN CONFINEMENT, WITH A THOUGHT ON THE ORIGIN OF WINGS IN BATS.

BY F. H. KING.

IN June, 1879, I obtained a litter of three flying squirrels, *Sciuropterus volucella* (Pall.) Geoff., from a nest built of small twigs and oak leaves, lined with grass, which was situated about ten feet from the ground in a small red oak standing in a grove of the same kind. The nest was a complete ball, from which the inmates escaped without any specially provided opening. No large trees of any kind exist within two miles of the grove, the locality, in its topography and vegetation, being an extension of the Minnesota prairies into Wisconsin.

The squirrels, so small when taken as to escape very readily between the wires of an ordinary canary-bird cage, became very tame and playful at once, they grew rapidly upon cow's

milk, which they lapped from the dish in the manner of a cat, except that the nose was held closer to the milk, so close, indeed, that it was with difficulty that the movements of the tongue could be observed.

They were strictly nocturnal and, at first, had regularly two frolics each night, beginning at 10.45 P. M., and at 3.30 A. M., which lasted from an hour to an hour and a half. During the whole of the first week of their captivity, the beginning of these frolics did not vary five minutes from the time stated, but after this they became more irregular in their beginning and more frequent. Their play consisted in running, jumping and gnawing simply, with nothing whatever of that rollicking roll-tumble-and-pull of the kitten. A favorite sport, out of the cage, consisted in climbing to some elevated point and then leaping and sailing to some distant lower level. Their early efforts in this direction were truly amusing; when the point of departure was reached, all fours were brought very near together and the head dropped with the nose pointing forward; in this attitude a number of quick vibrations of the body to and fro upon the feet, were made, which always suggested to me the act of winding themselves up preparatory to the leap, and the number and intensity of these vibrations was usually proportionate to the distance to be covered. They were not very accurate marksmen in the beginning, and oftener shot over the mark than under it. I was glad of this, too, for a favorite leap of theirs during their early efforts, was from the books on my secretary to the top of my head when sitting at the desk reading or writing. Not once did one of them alight on my nose or slide down my face, but very often they shot past my head, sliding down my back and even plunging through the back of the chair to the floor without touching me, to return by way of my legs to the station again, resolved to make a better record next time.

In their flight-like leaps, the four limbs were extended in such a manner as to throw them all into very nearly the same plane, thus stretching the parachute-like expansion of the skin tense and wide. It is interesting to observe, in this connection, that while on the flight, and especially just before alighting, the fore limbs are made to make a series of rapid and short vibrations not wholly unlike the movement in true flight. The fact may have been noted, and the thought which follows uttered by

others, but I have not observed it in my reading. Have we not in the modified structure of the flying squirrel, and in the tremor of its fore legs while sailing, the true key to that further modification in the bat which gives it the power of flight?

The common squirrels when they jump from any considerable height to the ground, have the habit of extending the legs in the manner of the flying squirrel, and at the same time of broadening the body very much horizontally; this is of manifest account in reducing the energy of impact due to the fall, and suggests possibly both the method and the occasion for the modification now possessed by the flying squirrels. The traction brought to bear upon the integument between the limbs in the effort to spread the legs, must stretch it, and may be supposed to have begun a modification which was perpetuated and intensified by natural selection until the modification in the flying squirrel was reached. The habit of spreading the legs may have had its origin partly in the mere effort to balance the body and maintain the desired attitude for alighting, and partly in the knowledge obtained experimentally in repeated acts of jumping.

It does not seem improbable that the development of wings in the bat may have been initiated in the same manner and have passed along essentially the same road, that is, the earlier ancestors of the bats may have had a dermal modification nearly identical with that of the flying squirrels, and which may have been used in much the same way for similar purposes. The next step, probably, in the development of the bat's wings, was the forming of the habit of vibrating the fore limbs together in a vertical plane, and the embryonic phase of that movement, it seems to me, may be represented in the tremor of the limbs mentioned as occurring in the flying squirrel under consideration.

In the effort to maintain the proper attitude of the body, we may have had the initiating factor; for if they were originally provided with parachute-like appendages, and used them as the flying squirrels do, it is probable that a similar vibratory movement would have been a necessity in order to keep the body in the attitude which would present the greatest surface to the air in falling. With the vibratory habit fixed, increased skill in executing it would of necessity prolong the leaps, and this is another step towards flying; and increased use and greater advantage

would operate, through natural selection, to bring about the final modifications.

I have never known wild animals that became so perfectly familiar and confiding as these young squirrels did; and they seemed to get far more enjoyment from playing upon my person than in any other place, running in and out of pockets, and between my coat and vest. After the frolic was over they always esteemed it a great favor if I would allow them to crawl into my vest in front and go to sleep there, where they felt the warmth of my body, and it was very rare indeed, during the first six months, that they failed to ask the privilege; indeed they came to consider themselves abused if turned out. When forced to go to sleep by themselves, the attitude taken was amusing, the nose was placed upon the table or other object it happened to be upon, and then it would walk forward over it, rolling itself up until the nose almost protruded from between the hind legs; the tail was then wrapped in a horizontal coil about the feet, and the result was an exquisite little ball of life in soft fur which it seemed almost sacrilegious to touch. If they escaped from the cage during the night, I was sure to be warned of the fact by their coming into the bed to roll themselves up close to my face or neck. They would very rarely return to the nest in the cage to sleep when the play was over. One of them found its way, while clambering about on the bed, between a pair of flannel blankets where it went to sleep near the foot, and always after that, if left to himself, he would find that spot to sleep.

So far as I observed, they exhibited no lonesomeness when left without a playmate, nor did I ever observe them play with one another, neither did they quarrel.

Before I procured a suitable cage, one of the three squirrels escaped. The other two derived great enjoyment running in the wheel, and in this sport the two would very often participate at the same time, but not, apparently, because the enjoyment was greater. In this sport one of them was so unfortunate as to break one of his hind legs above the heel; I splinted it carefully for him, securing the splints with thread. To this treatment he objected emphatically, scolding and pinching much during the operation, and when I returned at noon he had cut the threads and removed the splints. I could not replace them until evening; when I could attend to the little patient he was placed in my

hand, where he lay upon his back without a struggle, nor offering to bite, except once when the pain seemed greater than he could endure, and then he only pressed his nose against my finger with his mouth closed. During the whole operation those keen, full, black eyes gazed steadily into my own without following, so far as I could observe, the movements about him. He did not remove the splints a second time, nor did I see him make any effort to do so. When the bones had knit together sufficiently, I removed the splints, and he used his leg well but it was a little stiff.

Did this squirrel, after wearing the splints for a short time, find that the pain was more intense without them than with them? Did he discover on removing the splints an increase of pain, and connect that increase as an effect with its cause? Did he connect the presence of the splints upon his leg for the first time with the treatment he had received in the morning? Had he reached the conclusion that the first treatment was for his relief and, therefore, would submit to a second treatment? Had he learned through his experience with the first splint on and off, that it was, for the time, the right thing in the right place? And did that experience lead to a decision not to remove the splints a second time? If these questions are answered in the affirmative, this little squirrel manifested no low degree of intelligence.

Before the month of October following the capture of these three squirrels, two of them had escaped, Skip alone remained and in regard to his preferences as to kinds of food, it may be said that he preferred nuts to anything else, but would also eat apples, cakes of various kinds and bread with apparent relish. Occasionally he would take a little fresh meat, both raw and cooked, but the amount was always small. While the three squirrels were together and quite young, I introduced a large moth, *Saturnia io*, into the cage; this resulted in a frantic struggle on the part of the squirrels, each struggling for the moth; it was soon captured, the wings torn from the body, and the fleshy abdomen, charged with eggs, eaten by one of them. They would also capture and kill any beetles placed in the cage, but would rarely eat them. I once introduced a young chipping sparrow alive, not yet feathered; it was seized instantly and killed, but no part of it was eaten. Two squirrels of the same species which I

now have in confinement eat birds' eggs with great satisfaction, even when plenty of nuts of three kinds are before them.

After the weather began to grow cold I placed, one evening, on the floor a handful of acorns before Skip was let out. He began his frolic as usual, and finally ran upon them.

The circumstances were such that the acorns awakened in him a new and intense emotion which in an instant seemed to fill his whole being to overflowing. For a few minutes he appeared transformed into a wild squirrel and went bounding about the room shying from objects with which he was perfectly familiar, and starting at the slightest noise. He soon returned to the pile of nuts and took one of them in his mouth, running with it to a corner of the room, where he made a hurried, eager effort to bury it, thumping the acorn upon the floor as if he was endeavoring to push it beneath the surface. After from three to five thrusts, made as rapidly as one can count without separating the words, he made as many strokes with his fore feet upon the carpet, scratching as if to cover the acorn up. This done he hurried back to the pile of acorns, seized another, rushed back to the same corner again, going through the same motions as before. I kept his pile supplied, and he worked during a full half hour, depositing a few nuts in all corners of the room, behind table legs, behind the books in my secretary and in the pits made by the tie-buttons in all the upholstered chairs. The next evening before letting him into the room, I placed an assortment of nuts upon the floor, among which were acorns, hazel-nuts, hickory-nuts, pecans and English walnuts, all of which he had been fed upon frequently, exhibiting but little preference for either, so far as I observed.

On discovering the pile, Skip did not appear agitated as on the previous evening, but set at once to carrying off the acorns and hazel-nuts, hiding them with the same motions as before; but to my surprise he touched none of the other nuts. I tried him on succeeding nights with the same, and to me strange results, for acorns and hazel-nuts are the only ones that grow in the vicinity where the squirrels were taken. The pig-nut hickory is found in abundance not more than ten miles distant.

Have we here inherited mental attributes so strong as not only to originate the generic act of storing up nuts on the approach of cold weather, but so specific a form of it as a selection of the two

kinds of nuts from among three others which, beyond much question, were the only ones of the five named with which his near ancestors had anything to do? It should be stated in this connection that the squirrel had eaten of the other nuts during at least two months prior to the selection in question, with as much apparent relish as he evinced for either the hazel-nuts or acorns. This particular squirrel, only about five months old, had had no experience whatever with nuts except in confinement, and of course had never before attempted to bury them. Have we in this instance and in similar ones, evidence that an act, executed repeatedly during particular seasonal conditions, and under certain sense-impressions, as sight and smell, may impart so definite a set to the organization as that it shall be transmitted to an offspring? Is this set a molecular one and located in the nervous tissue? Is it so sensitive that if, when the body is experiencing those seasonal changes due to the change of seasons in the earth during which the original set had its origin, a combination of vibrations (those accompanying the sight and smell of an acorn, for example) like those which were instrumental in producing the set, are again imposed upon the nervous tissues, similar feelings will be awakened which tend to culminate in a desire like the ones which had prompted former generations to the act in question? And in this way to a repetition of that act? Did not Skip on the night in question experience a true recollection in which the memory he had inherited was jogged by the combination of the sight and smell of acorns and the systemic feeling of approaching winter?

On the 27th of June, 1880, I left Skip with a little girl to be cared for during my absence, which lasted through the summer; when we met again, about the middle of September, Skip showed unmistakable signs of a distinct remembrance of me by playing upon my person, in his usual manner, with great freedom. The most decided test, however, of his keen memory, was exhibited when he was allowed to play in the closet where Mrs. King's wardrobe hung beside my own. He played with unusual vigor and for a long time upon my garments, running in and out of pockets, but exhibited great caution in touching hers, only alighting upon them to jump to some of mine. He had never seen Mrs. King before the evening on which this frolic occurred.